6.0 OZONE TRENDS AND WEEKDAY/WEEKEND EFFECTS

6.1 Introduction

As discussed in more detail elsewhere in this report (*i.e.*, section 4.0), an initial examination of the ozone air quality data for the 1986 through 1993 smog seasons revealed a substantial downward trend both in the number of first stage ozone alerts and in a variety of other air quality metrics for ozone for all three areas of the SoCAB: western, mid-basin and eastern. This preliminary examination also showed a distinct trend towards more of the highest daily ozone values occurring on weekend days rather than on weekdays.

This observation agreed with findings for earlier years (*i.e.*, the late 1970's through the mid-1980's) reported by several researchers (*e.g.*, Horie 1988; Hoggan *et al*. 1989). In particular, Horie (1988) examined the weekday/weekend differences for portions of the two three-year time periods 1975-77 and 1984-86 which had apparently similar meteorological conditions, while Hoggan *et al.* (1989) examined the weekday/weekend differences in the six criteria pollutants for three different 3-year time periods (1978-80, 1982-84, and 1985-87). A number of other earlier investigations of weekday/weekend effects have been reported as well (Cleveland *et al*. 1974; Lebron 1975; Levitt and Chock 1975; Elkus and Wilson 1977; Graedel *et al.* 1977; Zeldin *et al*. 1989; Hoggan *et al*. 1989). However, to our knowledge, no detailed analysis of weekend/weekday ozone differences in the SoCAB for the eight-year period 1986-1993 has been reported prior to our present study. In this section of the report, we describe various analyses of weekday/weekend differences in SoCAB air quality.

6.2 Seasonal Mean Daily Maximum Ozone By Day of the Week

The ozone database (1986-93) was analyzed for differences in daily ozone maxima on weekdays vs. weekend days for the air pollution season (May-October). Data for selected stations in three different geographical areas [*i.e.*, western (or coastal), mid-basin, and eastern] were analyzed to identify weekday/weekend differences as a function of location in the Basin. The West LA and Central LA stations were used for the western area, Pasadena and Azusa for the mid-basin area, and Redlands and Riverside for the eastern area.

The ozone database contains hourly observations for each day for all stations. This database was analyzed to determine the daily maximum ozone concentration for each day of the week, and the mean daily maximum ozone concentration for the entire air pollution season (May-October) for each day of the week. The standard deviations for each day of the week were also computed to examine the degree of variation in the daily ozone peaks.

As an example, daily maximum ozone values for Azusa for (1 May - 31 October) 1986 are shown in Table 6-1. Although there is a clear trend toward higher mean daily maximum ozone values as the week progresses, with the highest values found for weekend days, the difference in the means is much smaller than the sum of the standard deviations. The standard deviations for all days of the week are substantial, reflecting the high degree of variation in daily maximum ozone values at Azusa even during the smog season. Similar results were obtained from analyses of ozone data for the West LA and Pasadena stations.

These results suggest that simple averages of daily ozone maxima are not a useful metric for distinguishing weekday/weekend differences. We were then led to examine other metrics, including an "exposure"-type metric (*e.g.*, cumulative pphm-hours above the Federal ozone standard).

6.3 Daily Maximum Ozone Distributions for Weekdays vs. Weekend Days

For the 1986-93 period, daily maximum ozone data for stations at Central LA, Azusa and Riverside were examined for weekday/weekend differences in the distribution of ozone concentrations (Figure 6-1 through Figure 6-24). In this analysis, Monday and Tuesday were used as a representative pair of weekdays to compare with Saturday/Sunday data. The Monday/Tuesday and Saturday/Sunday distributions of daily maximum ozone concentration levels for Azusa for the 1986 through 1993 air pollution seasons are shown in Figures 6-9 to 6-16. From these figures, it can be seen that many of the higher daily maximum ozone concentrations occurred on weekend days while the lower daily aaatable6-1

figure 6-1

figure 6-2

figure 6-3

figure 6-4

figure 6-5

figure 6-6

figure 6-7

figure 6-8

figure 6-9

figure 6-10

figure 6-11

figure 6-12

figure 6-13

figure 6-14

figure 6-15

figure 6-16

figure 6-17

figure 6-18

figure 6-19

figure 6-20

figure 6-21

figure 6-22

figure 6-23

figure 6-24

maximum concentrations were more frequent on the weekdays. Enhancement of this difference appeared to occur in the later years. Similar trends, are seen in the 1986-93 data for Central LA and, to a lesser degree, Riverside (Figures 6-1 through 6-8 and Figures 6-17 through 6-24, respectively).

A summary of WD/WE differences in daily ozone maxima by subregion is shown in Table 6-2 for the two four year periods (where weekday was defined as Wednesday and Thursday consistent with Horie, 1988). As shown elsewhere, for all subregions both WD and WE ozone was lower in the second four-year period. While WE minus WD differences were not statistically significant (by the t-test) for the 1986-89 period, these differences were significant at the 95% confidence level for all subregions except the Crestline station (*i.e.*, Mountain subregion) for the 1990-93 period. These results show that WD/WE differences in the daily ozone maxima increased between periods I and II in all subregions. In particular, there were substantially greater decreases in peak ozone on weekdays between the two periods then for weekend days.

6.4 Ozone First Stage Alerts and Cumulative Hourly Exposure for Weekdays vs. Weekend Days

As defined by the SCAQMD, a first stage alert for ozone is declared if the hourly-average ozone concentration equals or exceeds 20 pphm at any station in the SoCAB. Here we compare the number of ozone first stage alerts on weekdays and weekends days for the stations at Central LA, Azusa, and Riverside.

Figures 6-25 through 6-27 show the distribution of ozone first stage alerts by day of the week for these three stations for the entire eight-year period 1986-93. A greater number of ozone first stage alerts occurred on Saturday/Sunday than on weekdays at the Azusa station, and to some degree at the Central LA station.

Figures 6-28 through 6-30 show the number of ozone first stage alerts for each day of the week for each year during the period 1986-93 for the same three stations. A general decline is seen in the number of ozone first stage alerts for all days of the week over the eight-year period. The Azusa and Central LA stations appear to have experienced greater declines

than did the Riverside station.

table6-2

fig 6-25

fig 6-26

fig 6-27

fig 6-28

fig 6-29

fig 6-30

The cumulative hourly ozone exposure above the federal standard of 12 pphm was computed for each day of the air pollution season for each of the eight years of interest for the Central LA, Azusa and Riverside stations. The cumulative ozone exposure over the length of the air pollution season was then computed for each day of the week for each year (Figures 6-31 through 6-33). In general, the cumulative ozone exposure decreased over the eight-year period (1986-93) for all days of the week at all three stations. Ozone exceedances for Central LA and Azusa tended to be higher on weekend days than on weekdays, while this was not necessarily true for Riverside.

For the same three stations (Central LA, Azusa and Riverside) we examined by year in the period 1986-93 the number of hours equal to or above the National Ambient Air Quality Standard of 12 pphm. The data are shown in Table 6-3 along with the percentage of total monitoring hours at or above the standard. As can be seen, dramatic decreases in hours above the ozone NAAQS occurred for all three stations over the period between 1986 and 1993.

Table 6-3. Trends in hours equal or above the ozone NAAQS of 12 pphm.

* Total number of hours (May 1 - Oct 31) each year = 184*24 = 4416.

fig 6-31

fig 6-32

fig 6-33

6.5 Weekday/Weekend Analyses Using the CART Scheme

The CART scheme developed by Horie (1987) was used to bin the smog season days into the 10 different nodes of the tree in 3 different ways. First, the smog season days for each of the years 1986-93 were individually binned using the CART scheme. Then, all of the smog season days for 1986-89 were treated as one group for binning and those for 1990-93 were treated as a second group. Finally, the weekdays (here represented by Tuesday and Wednesday) and the weekend days (Saturday and Sunday) were separately binned for the two four-year periods 1986-89 and 1990-93. The present discussion focuses on the third of these applications of the CART scheme, the results of which are shown in Table 6-4. However, before proceeding, a *caveat* noted in Chapter 5 should be reiterated. As indicated by Instaweather (1989), if we were to develop a new CART tree for the period of years we are examining, it is quite likely that the nodes would be defined differently than in the CART tree developed by Horie (1987) using meteorological data from 1983-85. Such a task, however, was beyond the scope of the present project.

Several interesting results appear in Table 6-4. First, we see a general increase in mean (daily SoCAB maximum hourly-average) ozone value with node number in Horie's CART scheme. On average, the worst ozone days were defined by node 10, characterizing 6%-8% of the smog season days. However, the standard deviations were sufficiently large that many of the CART nodes cannot simply be considered as statistically distinct from each other. We will further address this issue later in this chapter when we examine the 10 days from each smog season with the highest hourly-average ozone concentrations and their associated CART classifications.

Nonetheless, this type of application of the CART scheme does allow us to make some comparisons between weekdays and weekend days, and between the two groups of smog seasons, in terms of the representative daily SoCAB maximum hourly-average ozone concentration under similar meteorological conditions. If we first compare 1986-89 weekdays with 1986-89 weekend days, we find little difference in the mean ozone values regardless of CART node classification. Of course, these results could be misleading if, for example, the two weekend days cannot be treated as being similar in

characteristic peak ozone value. There is in fact some evidence this might be the case, as we will discuss later in this chapter. Differences appear somewhat larger when we compare mean ozone values for 1990-93 weekdays with 1990-93 weekend days, especially those for nodes 6, 7, and 8. These nodes are distinguished from nodes 9 and 10 primarily by having a lower value of the 900 mb temperature.

Finally, we compared 1986-89 weekdays with 1990-93 weekdays and 1986-89 weekend days with 1990-93 weekend days. Here we see a general decrease in ozone values (except for the characteristically low-ozone concentration node 2 where a slight increase occurs); interestingly, though, for all of these CART nodes there was a larger decrease for weekdays than for weekend days.

6.6 Examination of Ten Days with Highest Hourly-Average Ozone Concentrations: 1986-89 vs. 1990-93

6.6.1 All Days

To further investigate the trends noted from application of the CART scheme, we examined the means of the ten highest daily hourly-average ozone concentrations for each of the four-year periods for each of the stations for which we have data (Table 6-5). In other words, we examined the trends as seen from the worst ozone days. We recognize that in limiting our examination to the ten days with the highest daily maximum hourly average ozone concentrations our results may not be as representative as those obtained from using a larger sample size (*e.g.*, 30 days) as is commonly used in ARB's Technical Support Division. We believe progress towards ozone standard attainment in the SoCAB is best measured by focusing on the worst ozone episodes. Therefore, we sacrificed the robustness offered by the larger sample size to gain the sensitivity derived from examination of only the worst days.

For 30 of the 32 stations listed (5 outside the SoCAB boundaries), the mean of the ten highest daily ozone concentrations for 1990-93 was less than that for 1986-89 (the two exceptions were Hemet and Lake Gregory/Crestline, at the far east end of the SoCAB, where slight increases occurred). If we now consider just the subset of stations where the **Table 6-5**. Means and standard deviations of the ten highest hourly average ozone

concentrations for 32 stations for the period 1986-90, and for the period 1990-93. Absolute and percentage differences in means are also shown. Ozone concentrations reported in pphm.

magnitude of the decrease in means exceeded the sum of the standard deviations, we found that only 1 of these 10 stations (Banning) was in the far east end of the SoCAB. Of the remainder, 5 stations were in the Coastal/Metropolitan subregions and 3 were in the San Gabriel Valley. Thus the most significant ozone decreases between the two four-year periods occurred in the western or middle portions of the Basin. An isopleth plot illustrating these results is shown in Figure 6-34. The most pronounced decrease in peak ozone occurred in the western portion of the Basin, corresponding generally to the area of maximum decrease in NO_x over this same eight year period (see Figure 6-35).

Data for the individual stations were then aggregated by subregion as shown in Table 6-6 to obtain the average percent decrease in the top ten ozone concentrations between 1986-89 and 1990-93 for each subregion. Apart from the Mountain subregion which included only the Crestline/Lake Gregory station and showed a 1.5% increase, all other subregions showed significant average decreases in peak ozone levels between the two periods, ranging from about 8% decrease for the Inland Valley to decreases of about 15% for the Coastal, Metropolitan, San Gabriel Valley and Inland subregions.

6.6.2 Weekdays and Weekend Days: Ozone Trends Between 1986-89 and 1990-93

Similar analyses to those shown in Table 6-5 were constructed for just weekdays (Tuesday and Wednesday) and for just weekend days (Saturday and Sunday). Results of these analyses are summarized by subregion of the SoCAB in Table 6-7. Subregions were designated following Horie (1988) though, as discussed earlier, we chose representative stations for each subregion based on the degree of completeness of the data record during our study period (1986-93).

With the exceptions of weekend days at Hemet and at Perris, we found that peak daily ozone values decreased throughout the Basin on both weekdays and weekend days. In the Coastal subregion, however, the decrease in the ten highest ozone concentrations on weekdays was less than that on weekend days (at all four of the stations used for this region), while the reverse was generally true for all of the other subregions. We also found the ratio of the magnitude of the decrease on weekdays to that on weekend days tended to increase

with distance from the coast. Specifically, for the Metropolitan asdfasdfsdfasdffig 6-34

fig 6-35

table 6-6

Table 6-7. Ozone trends for weekdays (WD) and for weekend days (WE) at stations in the SoCAB. Ozone concentrations reported in pphm.

subregion, the ratio of the mean weekday decrease to the mean weekend day decrease was 1.4, while for the San Gabriel Valley subregion it was 2.0, for the Inland subregion it was 1.9, and for the Inland Valley subregion it was 2.7.

6.6.3 Weekdays vs. Weekend Days: Ozone Differences Within Periods

Here we considered the difference in ten highest ozone concentrations between weekdays and weekend days for each of the two four-year periods (Table 6-8). The subregions and stations are the same as in Table 6-7.

For the period 1986-89, the mean of the ten highest daily ozone values on weekend days was higher than the mean for those on weekdays for all Coastal subregion stations considered, and for most (7 out of 9) of the Metropolitan subregion stations. However, the reverse was true for all of the Inland Valley subregion stations (as well as the one Mountain station), and for 2 out of 3 stations in both the San Gabriel Valley subregion and the Inland subregion.

For the period 1990-93, the means of the peak concentrations on the weekend days were higher than those on the weekdays for all stations in all subregions, with the exception of two stations in the far east end of the SoCAB: Crestline, and Banning (where the weekday means were only very slightly higher than those for weekend days). Comparing the magnitudes of the differences between the two four-year periods, we found a significant decrease in the degree to which the mean of the peak daily ozone values on weekend days exceeded that on weekdays in the Coastal subregion, while the reverse was true for the farther-inland subregions.

6.7 Examination of Individual Days with Highest Hourly-Average Ozone Concentrations for Each Year in the Period 1986-93

In Table 6-9 we present a listing of the 10 days with the highest hourly-average ozone values for each of the 8 smog seasons during the period 1986-93. (The number of days listed exceeds 10 for some of the years as all days tied at the 10th ranked value are included.) Here again, the decrease in highest ozone values through the eight-year period is evident.

Table 6-8. Weekday/weekend day differences in ozone concentrations at stations grouped by subregion in the SoCAB for 1986-89 and 1990-93. Ozone concentrations in pphm.

Table 6-9. The highest ozone concentrations in the SoCAB for each year in the period 1986-1993. Ozone concentrations reported in pphm. Redlands data missing for Sept. 26, 1986 to Oct. 31, 1986. San Bernardino data missing for May 1986. Data completeness is 89+% for all other years and stations.

Table 6-9. The highest ozone concentrations in the SoCAB for each year in the period 1986-1993 (Continued).

Table 6-9. The highest ozone concentrations in the SoCAB for each year in the period 1986-1993 (Continued).

For each day, the peak ozone value, the location(s), date and time(s) of occurrence, day of the week, and CART node (see Chapter 5) are listed. More of the peak ozone values were found to occur at Glendora than at all other locations combined. During just the second four-year period, a not insignificant number of these peak values also occurred at Crestline.

Summaries of the distributions by day of the week and CART node are provided at the end of Table 6-9. The distribution by day-of-the-week shows these highest ozone values occurred significantly more often on Saturdays than on Sundays, Mondays, Tuesdays, or Wednesdays. The CART node summary reveals that, although more of these peak ozone values occurred on days meteorologically classified as node 10 in the CART scheme, even this node captured only 46% of these occurrences. Thus the CART scheme, at least in the form developed by Horie (1987) for his data base, did not appear to yield any one particular set of meteorological conditions associated with the occurrence of the highest ozone values in the SoCAB.

6.8 NO_2/NO_x Trends and Weekday/Weekend Differences in Ambient NO_2 and NO_x Concentrations, and NO_2/NO_x Ratios

6.8.1 Previous Studies

As noted elsewhere, earlier studies have shown significant weekday/weekend (WD/WE) differences in ozone and ozone precursors (NO_x and ROG) in the SoCAB (Horie 1988; Hoggan *et al*., 1989). Horie (1988) analyzed the early morning 5-8 am PST NO_2 and NO_x data for the southern California region and found significant differences in NO_2 and NO_x concentrations, and NO_2/NO_x ratios between the period 1975-77 and the period 1984-86.

The South Coast Air Quality Management District has estimated that during the period 1976-82 there was a 30% reduction in ROG emissions and a 15% reduction in NO_x emissions in the SoCAB (SCAQMD 1983). From his analysis of 5-8 am PST ambient air concentration, Horie (1988) found a 10-15% decrease in NO_2, a 20-30% decrease in NO_x, and a 10-30% increase in the NO_2/NO_x ratio for the stations in the Coastal subregion he employed (Costa Mesa, Lennox, Long Beach). For the stations he used in the Metropolitan subregion (Central Los Angeles, Anaheim, La Habra), Horie found a 0-5% decrease in NO_2,

a 10-20% decrease in NO_x, and a 5-15% increase in their ratio between the two periods he investigated.

Horie (1988) also found significantly lower Saturday and Sunday levels of NO_2 and NO_x in both the Coastal and Metropolitan subregions for the time periods 1975-77 and 1984-86. The morning levels of NO_2 were found to be 10-20% lower and the morning levels of NO_x were found to be 30-40% lower on weekend-days than on weekdays. However, the NO_2/NO_x ratio was found to be higher by 20-40% on weekend-days as compared to weekdays.

Our initial goal was to extend the work of Horie (1988) to the eight-year period being investigated in the present study. Our first objective was to determine whether significant changes in primary pollutant concentrations occurred between the periods covered by Horie's study and the 1986-93 period of the present study. Inherent in both Horie's analysis and ours is the assumption that early morning ambient air NO_x concentration data for the west side of the SoCAB can be taken to reflect primary emissions of NO_x from mobile and stationary sources. Conditions which are consistent with this assumption for the 5-8 am PST (6-9 am PDT) period are very low wind speeds, relatively low solar insolation (between sunrise and 8 am), and a low-level inversion.

For comparison with Horie's data, the WD/WE differences in levels of NO_2, NO_x and their ratio in the Coastal and Metropolitan subregions were examined, and to minimize the influence of year-to-year meteorological variations, four-year averages for 1986-89 were compared to the four-year averages for 1990-93. Again to facilitate comparison with Horie (1988), the four-year averages were computed for Saturdays, Sundays, and Mondays, and for Wednesdays and Thursdays which were combined together as "typical" weekdays. Horie (1988) justified these choices by suggesting that weekend day emissions would differ from those on weekdays because, for example, many "stationary emission sources are not in operation on Sundays." Similarly, the morning commuter traffic that significantly contributes to high NO_x and VOC emissions on weekdays is not as prevalent on Saturdays and is even lower on Sundays (Zeldin *et al.* 1989). In addition, Horie and Zeldin *et al.* (1989) distinguished Monday ambient concentrations of NO_x from those of the other weekdays in

terms of reduced carryover of NO_x emissions from weekend-days (Zeldin *et al.* 1989).

6.8.2 Calculation of Mean Morning NO_2 and NO_x Concentrations and NO_2/NO_x Ratios

The mean NO_2 and NO_x ambient concentrations for the 5-8 am PST period were calculated for each day in the smog season for three stations in the Coastal subregion (as defined by Horie 1988) for the eight-year period of this study. The daily mean ratio was obtained by dividing the daily mean NO_2 by the daily mean NO_x and averaging these means for all three stations in the Coastal subregion. The same procedure was used to calculate the Metropolitan daily mean NO_2, NO_x, and NO_2/NO_x ratio. In the event the daily mean NO_2 and NO_x ambient concentrations for a given station in a subregion were both 0 pphm, the daily ratio was equated to zero and not included in calculating the daily mean ratio for that subregion. Less than 5% of the NO_2 and NO_x daily means for any given station were both observed to be zero.

It should be noted that the mean of the NO_2/NO_x ratios calculated from averaging the individual daily ratios will not necessarily be the same as the ratio calculated from the mean NO_2 and mean NO_x values. This explains the differences observed in Tables 6-10 and 6-11 between the reported values of the NO_2/NO_x ratio and the values that would be obtained by dividing the reported NO_2 means by the reported NO_x means.

Table 6-10 shows the mean morning concentrations of NO_2 and NO_x, and the NO_2/NO_x ratios for the Coastal and Metropolitan subregions for 1986-89 and Table 6-11 shows the mean morning concentrations of NO_2 and NO_x, and the NO_2/NO_x ratios for 1990-93. The following differences were observed between weekdays, weekend days and Mondays for the two four-year periods under study here.

WD vs. Saturday: Taking the means of the NO_2 and NO_x concentrations and the NO_2/NO_x ratios for the combined Coastal and Metropolitan subregions for the period 1986-89, Saturdays had 18% lower NO_2 levels, 32% lower NO_x levels, and 17% higher NO_2/NO_x ratios than the weekday average. Similar results were found for the period 1990-93.

Table 6-10. Mean morning (5-8 am PST) concentrations of NO_2, NO_x (in pphm), and NO_2/NO_x ratios on selected weekdays (Wednesdays and Thursdays),

Saturdays, Sundays, and Mondays during May-October 1986-89.

	WD	Saturday		Sunday	Monday
Coastal					
Stat. Days	209	105		105	106
NO_2	3.10	2.56	2.35	2.93	
NO_x	8.05	5.71	4.95	7.65	
Ratio	0.39	0.44	0.48	0.39	
Metropolitan					
Stat. Days	209	105		105	106
NO_2	3.54	2.90	2.58	3.38	
NO_x	8.81	5.75	4.61	8.72	
Ratio	0.39	0.47	0.52	0.39	

Table 6-11. Mean morning (5-8 am PST) concentrations of NO_2, NO_x (in pphm), and NO_2/NO_x ratios on selected weekdays (Wednesdays and Thursdays), Saturdays, Sundays, and Mondays during May-October 1990-93.

	WD	Saturday		Sunday	Monday
Coastal					
Stat. Days	211	106		105	104
NO_2	2.65	2.18	1.92	2.37	
NO_x	7.77	5.23	3.75	6.27	
Ratio	0.37	0.43	0.48	0.41	
Metropolitan					
Stat. Days	211	106		105	104
NO_2	3.06	2.63	2.24	2.81	
NO_x	8.56	5.86	4.04	7.07	
Ratio	0.38	0.46	0.53	0.43	

WD vs. Sunday: Again, combining the data for the Coastal and Metropolitan

subregions, for the period 1986-89, Sunday had 26% lower NO_2 levels, 43% lower NO_x levels, and 28% higher NO_2/NO_x ratios than the weekday average. Corresponding values for the period 1990-93 were 27%, 52%, and 36% respectively.

WD vs. Monday: Combining the data for the Coastal and Metropolitan subregions, for the period 1986-89, NO_2 levels were 5% lower on Mondays than on weekdays, NO_x levels were 3% lower on Mondays, and NO_2/NO_x ratios were the same on weekdays and Mondays. For the period 1990-93, NO_2 levels were 9% lower on Mondays than on weekdays, NO_x levels were 18% lower on Mondays, and NO_2/NO_x ratios levels were 12% higher on Mondays as compared to the average weekday.

Thus, during the 1986-93 period, average morning NO_2 and NO_x ambient concentrations on weekend days were approximately 20-25% and 30-50% lower, respectively, than on weekdays (*i.e.*, Wednesdays/Thursdays) in the Coastal/Metropolitan subregions.

In general, these early morning ambient air concentration data suggest that for all smog season days taken together a modest decrease in emissions of NO_x occurred in the Coastal/Metropolitan subregions between the two four-year periods under study here. Specifically, combining the NO_x data for the two subregions, weekdays (as represented by Wednesday/Thursday) and Saturdays showed only a 3% decrease in NO_x concentrations between 1986-89 and 1990-93, while Sunday and Monday showed an 18% decrease in NO_x concentrations for the combined subregions. The change in NO_2 concentrations was more uniform across the days of the week, with decreases of 14% for WD, 12% for Saturday, 16% for Sunday and 18% for Monday.

This result for all smog season days for the Coastal/Metropolitan subregions is in marked contrast to the case for the days corresponding to the top ten ozone episodes for which a much larger decrease in NO_x occurred between the two four-year periods for the Coastal/Metropolitan subregions (see below and Figure 6-35).

6.8.3 Statistical Significance of Observed Differences

The weekdays vs. weekend days and weekdays vs. Monday differences were analyzed using t-test statistics; Tables 6-12 and 6-13 show the results. Statisticallysignificant differences were observed between weekdays and Saturdays, and weekdays and Sundays, for NO_2, NO_x, and their ratio for both four-year periods. The differences between weekdays and Mondays were not statistically significant for NO_2, NO_x, and their ratio for 1986-89. In comparing weekdays with Mondays for the period 1990-93, statistically significant differences were found for NO_2 concentrations for the Coastal subregion and for NO_2/NO_x ratios for both Coastal and Metropolitan subregions.

6.8.4 NO_2 and NO_x Trends for Ten Highest Ozone Days

Tables 6-14 and 6-15 provide data for the mean 5-8 am (PST) NO_2 and NO_x ambient concentrations, respectively, for eighteen air monitoring stations for the ten highest ozone days in the two periods 1986-89 and 1990-93, as well as the differences in these means (as shown earlier in Figure 6-35). As can be seen from Figure 6-35, NO_x morning ambient concentrations for the ten highest days decreased markedly in the Coastal/Metropolitan subregion stations examined over this eight-year period, while there were generally modest decreases in the San Gabriel Valley and Inland Valley subregions, and in several cases (Pomona, Anaheim, Riverside and La Habra) modest increases in NO_x. Decreases in morning ambient NO_2 concentrations were more modest and more uniform across the Basin than was the case for NO_x. It is interesting that, as noted above, the western edge of the Basin was the site of both the largest decrease in morning ambient concentrations (and hence presumably emissions) of NO_x, and the largest percent decrease in ozone (see Figure 6-34) for the top ten ozone days at each station.

6.8.5 NO_2 Concentrations for 28 Highest and Middle Ozone Days

In connection with our earlier comparisons (see Chapter 5) between 28 highest ozone days vs. 28 "middle" ozone days for the period 1990-93 (for the stations at Glendora, Crestline, Fontana and Riverside), we have also examined the corresponding early morning

NO_2 ambient concentrations for these specific collections of days for

Table 6-12. t-Test for morning (5-8 am PST) concentrations of NO_2 and NO_x, and for NO_2/NO_x ratios for differences between weekdays and weekend-days and Mondays for (May-October) 1986-1989.

Variable/ Subregion	WD-Saturday t-statistic	WD-Sunday t-statistic	WD-Monday t-statistic
Coastal			
NO_2	4.64†	6.04†	1.41
NO_x	3.47†	4.71†	0.57
Ratio	-3.13†	-5.49†	0.00
Metropolitan			
NO_2	4.43†	6.51†	1.09
NO_x	4.62†	6.54†	0.12
Ratio	-5.01†	-8.36†	0.00

† Highly significant differences between two means ($p < 0.01$)

Table 6-13. t-Test for morning (5-8 am PST) concentrations of NO_2, NO_x, and NO_2/NO_x ratios for differences between weekdays and weekend-days and Mondays for (May-October) 1990-93.

Variable/ Subregion	WD-Saturday t-statistic	WD-Sunday t-statistic	WD-Monday t-statistic
Coastal			
NO_2	3.99†	6.27†	2.40†
NO_x	3.44†	5.75†	1.95§
Ratio	-3.68†	-6.90†	-2.44
Metropolitan			
NO_2	3.15†	5.95†	1.77§
NO_x	3.57†	6.25†	1.84§
Ratio	-4.28†	-8.56†	-2.66†

§ Significant differences between two means ($p < 0.05$)

† Highly significant differences between two means ($p < 0.01$)

Table 6-14. Average morning (5-8 am PST) NO_2 concentration (pphm) for top ten ozone days in the indicated periods.

Average Morning NO_2

P1 = Average morning (5-8 am PST) NO_2 concentrations for the top ten ozone days in 1986-89.
P2 = Average morning (5-8 am PST) NO_2 concentrations for the top ten ozone days in 1990-93.

Table 6-15. Average morning (5-8 am PST) NO_x concentration (pphm) for the top ten ozone days in the indicated periods.

P1 = Average morning (5-8 am PST) NO_x concentrations for the top ten ozone days in 1986-89.
P2 = Average morning (5-8 am PST) NO_x concentrations for the top ten ozone days in 1990-93.

twenty-one stations in the Basin.

In Table 6-16 are presented 5-8 am (PST) mean NO_2 ambient air concentrations for the 28 highest and 28 middle ozone days examined earlier, and their difference. From a comparison of the data in Tables 6-14 and 6-16, it can be seen that the magnitude of early morning NO_2 ambient concentrations generally correlated with the level of subsequent ozone on the same day. Specifically, for the 1990-93 period, the overall average morning NO_2 concentrations (for eighteen or twenty-one stations) was 5.9 pphm for the ten highest ozone days, 5.3 pphm for the 28 highest days and 3.7 pphm for the 28 middle days.

Table 6-16. Average morning (5-8 am PST) NO_2 concentrations (pphm) for 28 high and 28 middle ozone days.

Station	High-Ozone Days	Mid-Ozone Days	Difference[a]

[a] Including rounding.

6.9 Summary

Some of the findings of greatest interest from data presented in this chapter were as follows.

- As well documented earlier by the ARB, SCAQMD and others, substantial reductions in peak ozone concentrations occurred in all regions of the Basin and across all days of the week between 1986-89 and 1990-93, although the percentage reductions were greatest in the western and middle portions of the Basin. On average there were greater reductions on weekdays than on weekends and hence the differences in WD vs. WE daily ozone maxima increased in the 1990-93 period over the 1986-89 period.

- An examination of the worst ozone days, specifically the ten highest daily hourly-average ozone concentrations for each of the two four-year periods for each station for which data were available, showed the most pronounced percentage decrease in these highest ozone concentrations occurred in the western and middle portions of the Basin, corresponding generally to the area of maximum percentage decrease in early morning NO_x ambient concentrations for these same highest ozone days.

- The distribution by day-of-the-week of the ten (or more if there were ties) days with highest ozone concentrations in the Basin for each year in the period 1986-93, showed these episodes occurred significantly more often on Thursdays through Saturdays than on Sundays through Wednesdays.

- For the period 1990-93, the means of the peak ozone concentrations for the top ten days were higher on weekend days than on weekdays for all stations in all subregions (with the exceptions of Crestline and Banning). For the period 1986-89, this was true in general only for the Coastal subregion.

- On average, early morning ambient concentrations of NO_2 and NO_x during the eight-year period studied were lower by approximately 20-25% and 30-50%, respectively on weekend days than on typical weekdays in the Coastal/Metropolitan subregions.